PUBLIC AFFAIRS FORUM

An analysis of public policy issues and how they affect MRS members and the materials community...

Catching Up with DARPA

I assumed the position of Director of the Defense Advanced Research Projects Agency (DARPA) in June 2001. I cannot help but be amazed at the tremendous progress and innovation that has been accomplished by research in the physical sciences since I was last at the agency in 1986 as Director of the Strategic Technology Office.

Currently, DARPA's core technology investments include information technology, microsystems, microelectromechanical systems (MEMS), and complementary metal oxide semiconductors (CMOS), as well as technologies such as spin properties in semiconductors and molecular electronics, and, of course, materials research, which is the thread that binds many of the technologies and systems together. Investments in these core technologies comprise roughly 40% of our annual budget. To illustrate the diversity of our materials research program, let me take the opportunity to describe a few of our ongoing efforts.

The agency's philosophy in materials research is continually changing as new developments and discoveries are made that result in new needs for the defense community. For instance, about 10 years ago, electronic materials research was a hotbed of funding opportunities. Many of our current investments focus on exploiting these materials innovations for new-to-the-world computing architectures using the spin of an electron as opposed

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to its charge, or using self-assembled molecules to compute instead of lithographically defined silicon.

Clean air and water are crucial to the sustained operation of our warfighters. To address this problem, our air-purification effort focuses on destroying or neutralizing pathogens and toxins before they enter the body. Specifically, DARPA is developing air-purification systems using microfibrous materials in combination with "designer" nanoadsorptive materials that act as a carrier technology. Together, they provide enhanced chemical vapor adsorption and particulate filtration. The filtration media being developed exhibit lower pressure drops and greater capacity against chemical warfare agents.

DARPA is also developing a number of innovative approaches to desalt, disinfect, and purify water from any source in the field. Technologies include the use of mixed oxidants and novel and improved filtration methods. The program is also developing new ways to think about both reverse and forward osmosis (RO and FO) processes to desalt seawater. The RO units are pressure-pulsed, akin to the way the kidney cleanses salts from the bloodstream; biologically inspired pulsing increases both the water flux and water quality. The program is also developing FO bags that use a chemical potential, driving solutes such as fructose and proteins, to push pure water through the membrane (as opposed to using mechanical pressure). This is a way of purifying and desalting water using no external energy.

In FY 1999, the Flexible Emissive Display program was initiated to develop and demonstrate large-area, high-resolution, flexible, emissive, and rugged displays for defense applications. Last year, the program conducted demonstrations in three key technology areas: backplanes, (i.e., flexible electronic circuits) emissive materials, and substrates. This year, the program is demonstrating a low-cost, high-speed, roll-to-roll assembly process for plastic-film liquid-crystal displays. By the end of this year, we expect to demonstrate emissive, color-display video capable of >80 lines per inch on a flexible substrate.

Our Structural Materials program is focused on weight-reduction and performance-enhancement for defense systems. We are working with amorphous metals and multifunctional materials for ultralightweight ground vehicles and spacecraft. With the former, we are exploiting the unique toughness, strength, and ballistic properties of amorphous metals for ballistic-resistant ship structures and as a replacement for depleted uranium in antiarmor projectiles. Last year we developed approaches for processing these materials in bulk at reasonable cost; this year we are evaluating the properties of these materials in the context of making significant improvements for defense applications.

The Multifunctional Materials program combines structure with critical system functions such as power, repair, and ballistic protection. For example, this year the program is demonstrating the use of fuel cells whose physical structure also serves as the functional structure for a platform such as a weight-sensitive micro air vehicle (in which the vehicle itself is <6 in. in any one dimension such as length or width). In other words, the micro air vehicle can have a wing that is the structure, antenna, and fuel-cell wall (hydrogen inside, air outside). Next year the program will look at structures that combine ballistic protection with structure.

The Meta-Materials program is defined as engineered (nano) composites that exhibit superior properties not found in nature and not observed in the constituent materials. Two good examples of meta-materials are photonic-bandgap devices and left-handed materials (i.e., materials that exhibit a negative index of refraction). An objective of the program is to preserve the superior properties of low-dimensional systems in new bulk materials constructed from these unit-cell building blocks that are engineered to exploit small-scale physics. The program promises to deliver low-frequency (>1 MHz) meta-materials with superior magnetic properties for power electronics, electric propulsion, and power generation, and high-frequency (<1 MHz) meta-materials with superior broadband microwave and optical properties for communication and wireless applications.

The Smart Materials and Structures Demonstrations program has applied existing smart materials to reduce noise and vibration and to achieve aerodynamic and hydrodynamic flow control. DARPA has demonstrated small, high-bandwidth devices for acoustic-signature reduction in marine machinery; shape-memory-alloy (SMA) actuators to control the shape and attitude of fighter aircraft engine inlets; flexible skins with embedded SMA wires for continuous-control surface-shape changes, resulting in improved aerodynamic performance; and small, powerful actuators that fit into helicopter blades, for noise and vibration reduction. We are also exploring novel ways to make compact hybrid actuators that will employ smart materials to create a new class of efficient, high-energy-density actuators in a package that is smaller and lighter than conventional hydraulic and electromagnetic actuators with similar power ratings.

This is a taste of DARPA's investment philosophy and ongoing programs in materials research. We are in a remarkable period of technological discovery. We intend to provide the resources and research environment to foster continued efforts in this important area and to exploit these and other new opportunities as they arise.

However, DARPA does not work alone in pursuing its basic and applied research programs. We continue to coordinate our basic research programs with the military services, primarily through organizations such as the Army Research Office, the Office of Naval Research, and the Air Force Office of Scientific Research.

DARPA is an agency that thrives on new technological opportunities and discoveries. Your suggestions and comments are most welcome.

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